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MIGHTY CHIPS

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Something exciting is going on. But like most significant events, it is not happening quickly. Spurred on by developments in integrated circuit technology, a new generation of personal computers is taking shape, and the IBM PC and its clones are at the forefront.

As IBM PC users, it's sometimes hard to remember that the inanimate metal boxes in front of us are susceptible to evolution. But occasionally a product is introduced that forces the complete redesign of our personal computers.

Integrated circuits (ICs), the devices that bring intelligence to our machines, have reached a new level of technological achievement, and now the computers that use them must advance as well. Strange as it seems, these small silicon chips are setting the guidelines for the next generation of personal computers.

THE CHIP MAKERS

Now that personal computers have caught on, the semiconductor manufacturers who make ICs are eyeing the swelling market for personal computer ICs.

Dozens of newly developed semiconductor chips are being aimed at the personal computer market. These chips range from hard disk controllers that speed access time to linear predictive coding processors for speech recognition. With these new ICs driving personal computer design, we'll soon see machines we once only reasoned would exist: diskless computers running a wide array of software loaded over telephone lines; computers that display text exactly as it will be printed, with justified margins, superscripts and subscripts, and bold and italic typefaces on screen; and systems with greater, more accessible graphics.

As computer design is simplified by these advanced ICs, product differentiation will become greater. This portends the death of those PC clones capable only of basic spreadsheet and word processing operations. Instead, to survive in the increasingly cost-competitive, standardized personal computer market, small-system manufacturers will tailor their products for niche markets.

BIG BLUE

Intel Corporation, located in Northern California's renowned Silicon Valley, is one of the largest and most innovative chip manufacturers in the industry. IBM has been committed to Intel products for years; the PC is built around Intel's 8088 microprocessor and, as recently as late 1982, IBM invested \$225 million in a minority share of Intel stock. A commitment this size is a good indicator of IBM's faith in Intel products. IBM's good faith and multimillion-dollar investment is guaranteed by Intel's long-standing promise that software written for the 8088 will run on all its future processors.

By taking a close look at the Intel ICs, we can gain valuable insight into the capabilities of the IBM PCs that will be built around them. The design philosophy of Intel's IC family differs radically from that of competitors Motorola,

National Semiconductor, and Zilog. Diverse chip designs mean that the system designs of the IBM PC and its competitors, such as Apple's Lisa (based on the Motorola 6800 microprocessor), will also be radically different.

THE MICROPROCESSORS

Of the many Intel chips being produced, some will have a greater impact on the computer industry than others. In the vanguard will be the new microprocessors.

Design of the PC was shaped by IBM's surprising selection of the 8088. This choice caught most industry observers off guard since IBM, also the world's largest semiconductor manufacturer, had traditionally used its own designs for computer logic. Once Big Blue settled on the 8088, Intel's design philosophy was firmly implanted in the PC—from the 8088's segmented memory scheme to its 16-bit registers and 8-bit bus.

Like the 8088, each of the four microprocessors Intel is now readying for production could dramatically influence the design and performance of tomorrow's PCs.

The 80186. The recipe for putting an entire central processing unit (CPU) board on one chip is easy. Take an 8086 (the 16-bit bus big brother of the 8088), speed it up, and then add most of the support chips essential to making the 8086 run in a personal computer. Reduce the size with the help of computer-aided design until all the chips fit onto one sliver of silicon, and *voilà*, you have the 80186 (186), an entire motherboard on a chip.

While firming up plans for full-scale production of the 186, Intel is currently providing samples of the chip to computer manufacturers, including MAD Computer and Durango Systems. The rewards for using this newest chip are many: manufacturing costs are cut since a single IC is less expensive to buy than a boardful of them; physical CPU size is reduced, opening the way to shrink overall computer size or to put more power in the same box; and development time is cut for computer designers, which means considerable savings for system makers.

The 80188. If the 186 is too rich for your taste, the 80188 (188) may be more suitable. As with the 186, the 188's core CPU and support chips are melded on a single IC; like the 8088, however, the 188 has an 8-bit interface to the outside world (the 186 has a 16-bit interface). The 188 decreases costs by allowing computer manufacturers to use less expensive 8-bit peripherals. Although the 186 has received more publicity so far, the 188, aimed squarely at the massive 8-bit computer market, is expected to be used in greater numbers, at least in the short term.

The 80286. Powerful multiuser systems will benefit the most from the 80286 (286), possibly the most powerful microprocessor commercially available to date. Squeezing 150,000 transistors on a chip, the 286's designers have integrated a pair of HMOS-III (Intel's own proprietary process technology) 8086s and numerous other very large scale integration (VLSI) components. The resultant chip is two to three times faster than the Motorola 68000 even though both chips can address about the same amount of

memory. The 286 has very high speed (1.5 million instructions per second, five to six times faster than the 8086), about 16 megabytes worth of addressable physical memory, the ability to address a virtual memory of 1 gigabyte per task (equal to the capacity of 100 IBM XT Winchester drives), and the ability to provide several layers of multiuser security on chip.

The 80386. Not yet built, the 80386 (386) is promised for 1984, but the release date may slide to 1985. If the 286 is vastly more powerful than the 8088 or 8086, then the 386's potential is staggering. Complementary metallic oxide semiconductor (CMOS) process technology, which lowers power consumption, is being used to build this 32-bit chip. Intel, Motorola, and National Semiconductor are already jockeying for position in what will be an intense competition for the 32-bit market. Motorola is claiming that its 68020 will be the first widely available 32-bit microprocessor when it is introduced later this year, although NCR has already scooped the industry with its 32-bit chip. Hewlett-Packard, not to be outdone, has put 450,000 transistors on a single proprietary 32-bit microprocessor, which is used in the \$20,000 to \$30,000 HP 9000 work station.

How will these processors impact the personal computers that use them? The most obvious effect will be faster performance. Even the budget model 188 boasts two to five times the instruction and execution speed of the 8088 in today's PC. A 286 is about twice again as fast as the 188, and next year's data-gobbling 386 will have more speed than anyone can immediately use.

Since the 188 is ideal for low-priced portable computers, it ceates the ironic probability that a PC-compatible portable may soon be available that will run the IBM PC's full line of software and run it faster than the full-sized PC.

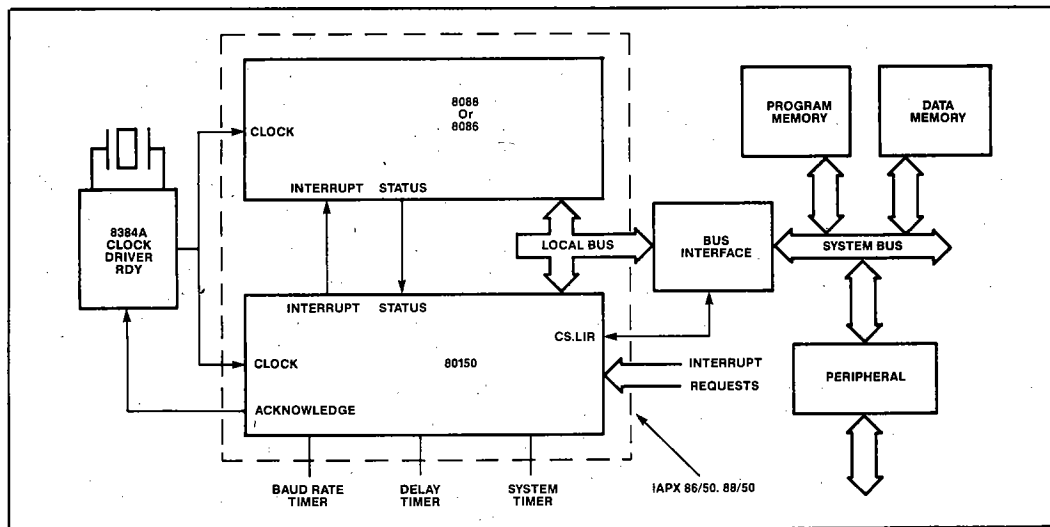
SOFTWARE ON SILICON

One chip ready to plug into the next generation of personal computers is the 80150 (150) CP/M software-in-silicon operating system. A complete CP/M-86 operating system is stored in ROM on this chip, along with drivers for input and output devices.

Use of a 150 CP/M chip will eliminate the traditional booting up procedure of loading an operating system disk and reading its contents into operating RAM. Instead, the user will simply turn on the computer and press a CP/M-86 button. Again and more importantly, this chip lowers overall computer production costs since a disk drive and attendant control circuits are replaced by a solitary chip.

Another chip, similar to the 150, has Intel's proprietary RMX operating system in silicon. This little-known RMX chip is also suitable for present and future IBM PCs.

Many people question the wisdom of putting software in silicon. "Software should be soft," says Bill Gates, chairman of the board at Microsoft. He points out that operating systems are constantly updated; for instance, Microsoft will soon offer a revised version of MS-DOS that supports networking. Such updates can't readily be added to a hardware production line and certainly won't help the ROM chips already in users' computers.



BLOCK DIAGRAM OF INTEL'S 80150 CP/M ON A CHIP WITH THE 8088 OR 8086 MICROPROCESSOR

Still, Intel argues that its choice of CP/M makes the 150 practical. "We picked CP/M because it is a mature operating system," Says Intel's product marketing engineer for software on silicon, Carl Buck. "We'd have more difficulty with a less developed product." The many versions of MS-DOS helped eliminate that operating system from consideration. Yet according to Digital Research President John Rowley, Intel left some room on the 150 chip to add to CP/M in the future.

Also, use of the 150 CP/M chip doesn't preclude the use of other operating systems. PC-DOS could still be loaded into a system and run, making use of the 150's input/output drivers.

PORTABLES

Having software on silicon opens the way for very powerful diskless portable computers. The minimum configuration for a 188-based unit with the 150 CP/M operating system could include one or two BASIC applications programs in ROM, providing spreadsheet and word processing power in a unit the size of a keyboard with a small flip-up screen. Intel Product Marketing Engineer Tony Zingale suggests we may soon see truly usable portables selling for around \$500.

More ambitious and expensive portables could accept applications software over telephone lines, loading them into a variety of media. Several memory technologies will compete for room in portable computers, including magnetic bubble memories, already being used in the Grid and Teleram computers. Commercially available bubbles have 4 megabit capacity, while 10- to 16-megabit bubbles are projected for the near future. Japan's NEC reported a major breakthrough that within 5 years will allow bubbles to store 1 gigabit of data. Of course, 8 of those bits are needed to store 1 byte of data.

Vying with bubbles in some applications and complementing them in others are electronically programmable read-only memories, or EPROMs. Like ROM, EPROMs are nonvolatile chips. Unlike ROM, EPROMs can be reprogrammed. Intel now offers 256K EPROMs, and it is anticipated that other companies will offer 256K EPROMs before the year's end.

GRAPHICS

The space created on the motherboard by the 186 and friends will enable computer designers to add more graphics capability to their systems. Like the 150 there are co-processor chips ready for the task.

A pair of Intel ICs, the 82720 (720) graphics display controller and the 82730 (730) text co-processor, are touted as providing vastly enhanced and simplified displays. With the 730, text can be displayed on the computer screen as it will be printed out. Italics can be mixed with straight text, and superscripts and subscripts are shown without the annoying and often misleading arrows common in today's software.

Editing can be speeded up by the 730's support for split screens, multiple windows, dual cursors, smooth scrolling, and table-driven linked lists. Displays of up to 200 characters per row and 128 lines per screen can be supported, and unique character sets, such as Arabic or Japanese, can be built.

Even more capability can be added though the 720, an IC that works with or without the 730. Introduced in September 1982, the 720, a joint effort between Intel and NEC, is said to be integral to graphics plans for NEC's 8086-based Advanced Personal Computer.

One application in which the 720 and 730 will shine is opening windows on-screen. Most computer users are familiar with the ability of Apple's Lisa to link spreadsheets, graphics, and word processing through multiple displays, or windows, on one screen. Lisa uses memory-hungry software and dedicated hardware. Apple's initial release uses 1 full megabyte of RAM, and Lisa will soon be offered with 4M of internal memory in addition to a mandatory 5M hard disk.

For comparison, the IBM PC, limited by the range of the 8088, can address 1M tops. VisiCorp's *Visi/ON* promises Lisa-like graphics and program-linking capabilities for the IBM PC, with lower memory demands and no dedicated hardware other than a mouse. Although *Visi/ON* supposedly runs faster with an 8087 math co-processor, VisiCorp will not comment on whether its software will make use of the 720 or the 730.

BIT-MAPPED GRAPHICS

Both Lisa and *Visi/ON* use bit-mapping, a process that the 720 and the 730 are said to simplify. In plain words, to create an image on-screen, the electron gun that illuminates the screen must be positioned and then turned on and off. Data to do this is stored in RAM as a bit-map memory corresponding to positions of pixels lit on the screen. For one-level monochrome displays, 1 memory bit describes each pixel; for color and levels of grey, several bits must be used to describe each pixel.

Creating images is a lengthy chain of simple operations. In a system that uses the 8088 alone, the microprocessor is heavily burdened and the software runs slowly. Using complementary chips to take up part of the processing chore will speed up the process considerably. This is where the 720 and the 730 come in. By doing tasks such as looking up and manipulating a library of commonly used figures, quickly accessing the bit-map memory, and rewriting the bit map, both chips speed text and graphics operations.

FLAT VS. SEGMENTED MEMORY

Use of the 720 and the 730 demonstrates Intel's design philosophy and how this philosophy impacts the IBM PC. Computers such as Lisa that are based on the Motorola 68000 have a flat memory, while computers based on the 8088 or 8086 use segmented memory. According to Intel,

segmented memory (see "How the PC thinks," *PC World*, Vol. 1, No. 1) works better for text and graphics manipulation than its flat counterpart. Ordinarily in processing any string of characters, changing a single letter in a string of text means repositioning every character in a document. But since segmentation uses pointers to locate data in memory, only the pointers locating the beginning and the end of a passage of text have to be changed. Similarly, pointers in memory can be used to position bit-map data corresponding to multiple windows on-screen, eliminating the need to recalculate and manipulate the entire bit map. Segmented vs. flat memory has become somewhat of a religious issue in the semiconductor industry.

Intel and Motorola also differ on how much burden to put on the CPU. Motorola's 68000 is faster than the 8088 and the 8086 and can address more memory than either of those chips or the 188 or the 186. But the 186 and the 286 are substantially faster than the 68000. Also, the 286's ability to address 16M opens the way to using large memory segments, strengthening Intel's case for segmented memory.

In many 68000-based high-end systems the computer designers have decided to use a co-processor, either bit slice, or in one case, an 8086, to do graphics. Many people are skeptical of Intel's graphics approach, but Intel maintains that its approach will allow computer designers greater flexibility. In an ultimate system, multiple 720s and 730s could be combined to handle interactive windows under the direction of a 286 processor, while more complex imagery (beyond the practical ability of bit-mapping) could be managed by an 80287 math co-processor, the next generation cousin of the 8087. The creation of three-dimensional graphics that can be rotated onscreen for advanced computer-aided design and manufacturing systems, for instance, is best handled by Vector Graphics rather than bit-mapping.

SOFTWARE DEMANDS

Yet there is more to computer design than hardware. Software must be written to take advantage of the new IC's promise. In the case of the 286, no operating system yet exists that can take full advantage of its operating capabilities. Plug-ins currently on the market that add the 286 to the IBM PC provide little more than a faster 8086. Only new operating software will use the new chips to their fullest potential.

One solution on the horizon is a 286 version of XENIX due to be introduced mid-1983. XENIX, a multiuser operating system with a visual shell similar to MS-DOS, is a takeoff on Bell Labs' UNIX operating system. A licensing agreement among Intel, Bell Labs, and Microsoft, the author of XENIX and MS-DOS, is reported being negotiated. Negotiations between Intel and Digital Research to provide a CP/M variant for the 286 have been underway for some time but have reportedly stagnated.

For lower-end systems Microsoft is said to be upgrading MS-DOS to accommodate networking. This advance comes at the right time, as the 188 and 186 open up sockets that could be used for local area network chips such as the programmable Ethernet chip from Intel.

As long as software and hardware keep growing rapidly together, PC users will be offered a continuing stream of improved computers and ever more capable plug-in boards. The variety seems endless and next year's crop exciting.